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ATMOSPHERIC ENVIRONMENT AND HEALTH.[1]

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[Osborne House, Loughton, Essex, England, Dec 18, 1920.]

The wild animal which survives in the struggle for existence enjoys perfect fitness and health. On the other hand civilized man requires a volume to contain the list of diseases from which he suffers. Not only wild but domestic animals—horses, cattle, sheep, swine—do well on an open-air existence; they are far more subject to disease when closely confined in stalls. Stock breeders have not succeeded in using successfully artificial heat for the raising of stock, excepting the case of young chickens hatched in incubators. The experience of keepers of zoological gardens has led them to extend the opportunities of open-air life, in the case of animals brought from tropical countries.

Man, evolved some million years ago, has immense inborn power of resisting cold. The experience of shipwrecked people, and of citizen-soldiers exposed to the utmost rigors of weather in the trenches, shows this power. The soldiers in the great war, well-fed, clothed and exercised but at times wet, chilled and exhausted by war, were, compared to the civilian population at at home, exceptionally free from respiratory catarrh. Wild men, such as the Fuegians, stand exposure to most inclement weather with scanty or no clothing and no houses or artifical heat. They practice infanticide to keep the population down to the food supply. They, like the wild animal, shelter in thickets, or caves, where, owing to wind and temperature difference between their bodies and the atmosphere, there is free exchange of air.

The experience of open-air schools and sanatoria show that life spent largely in the open benefits the health of those subject to catarrhs, those with overnervous temperament, those with heart weakness, etc. London has two and New York not less than 120 such schools. The Japanese have carried out their wonderful development of artistic excellence in craftsmanship in slightly built dwellings with the aid, in cold weather, of nothing but charcoal braziers to warm their hands at, depending on clothes and exercise to keep their bodies warm. On the other hand, the endeavor in the last century or so of Europeans and Americans dwelling in the colder climates, has been toward building draughtless houses and securing inside these by artificial heating a climate similar to that on a still, oppressive warm summer day. The low cooling power of stagnant air of rooms artificially heated by radiators depresses the metabolism to a low level. In place of the body being kept warm naturally by the stimulation of cool air exciting muscular exercise and glanular activity and so enhancing the combustion of food, it is kept warm by the blanketing effect of warm stagnant air, so that sedentary occupations, amusements and rest can be carried out in warm comfort and a minimum of open-air muscular exercise be taken.

The body is fashioned by nature for the getting of food by active exercise, and upon the taking of such exercise depends the proper vigorous function of the digestive, respiratory and vascular organs. Consequent on this, too, is the vigor of the nervous system and keen enjoyment of life. So, too, the healthy state of joints, muscles and ligaments, and freedom from rheumatic pains depend upon proper exercise of the body, neither over use nor under use, either of which may be associated with mal-nutrition and lowered resistance to infection. The hothouse conditions of life suitable for the failing powers of the aged, the injured in a state of shock and those in the last stages of wasting disease are mistakenly supposed to be suitable for the young and healthy. The traditional fear of cold is handed down from mother to children at her knee. For fear of their "catching cold," they are confined indoors and overclothed. They are debilitated and exposed at the same time to massive infection in crowded places. They require well-chosen food containing all those vitamines or principles of growth which are found in milk, the young green shoots of plants, grain foods with the germ and outer layers not removed by the miller. At the same time they require the stimulation of abundant open-air exercise to make them eat and metabolize their food. Household expenses will go up as more food is eaten by children excited by open-air exercise to keep appetite, but an immense national economy will result from a healthy, vigorous, efficient people.

Man, with his erect posture, has to withstand the influence of gravity, which weighs down his viscera and tends to make his blood and body fluids sink to the lower parts. This influence is naturally resisted by the tone of the muscles, skin, and other membranes which by confining the body prevent overdistension of dependent parts, and by muscular exercise, such as walking, and the consequent deep breathing, which together pump the blood back from the capillaries and peripherial veins to the heart, and at the same time most effectually massage the abdominal viscera. Such massage keeps the circulation active through the bowels, liver, etc., and helps those movements of the bowels which further the proper digestion and absorption of food and prevent constipation. Unnatural bacterial fermentations, with consequent poisoning, arise in the bowels from lack of exercise, particularly in those who indulge in the pleasures of the table. Food is taken by these which is not absorbed and

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utilized. In others appetite is reduced by the sedentary indoor life and constipation and dyspepsia result with a condition of deficient feeding and the debility of the semi-starved. The deep breathing excited by exercise not only furthers the circulation and the activity of the bowels, liver, etc., but secures the proper functioning of an adequate blood stream through all parts of the lungs.

Out of doors the skin is cooled and dried by the wind and water is evaporated from it—the wind freely ventilating the clothes. The air on the most calm and oppressive day out of doors is never as still as it is in a shut-up room. The skin is also warmed by the radiant energy of the sun, and this, too, actively causes evaporation. The wind and the sun affect the flow of water from lymph and blood through the skin, the wind cools the blood in one part, the sun warms it in another, the shorter sun rays act chemically on the white skin as evidenced by sunburn and pigmentation. There is reason to think that the skin is a great seat of production of immune substances which protect us against infection. Exposure of the skin to sun and wind has a profound effect upon it, and through it on the health of the body. Cool winds insure the removal of the body heat by convection, and keep the cutaneous vessels constricted so that the blood is driven in greater volume through the viscera; the sun and warmth dilate the cutaneous vessels and enhance the flow through the skin, and excite perspiration. These to-and-fro changes of the skin's condition make for health. The monotonous life spent in an environment of overwarm, stagnant, and moist air entangled in their clothes when people are confined in rooms, often crowded, is contrary to those naturally changing conditions which pertain out of doors. The air which is breathed into the lungs, whatever be its content of moisture or its temperature, is breathed out approximately at body temperature and saturated with moisture at this temperature. What matters to the skin and respiratory membrane is not the relative humidity, but the actual vapor pressure of the air which comes in contact with it. Cold saturated air is excessively dry when warmed up to body temperature, and takes up much moisture from the body; warm saturated air (or even half-saturated), far less.

The vapor pressure of saturated air at 20° C. is 0.96 mm. Hg.; at −10° C., 2.16; at 0° C., 4.58; at 10° C., 9.21; at 20° C., 17.54; at 30° C., 31.83; at 35° C., 42.2; at 40° C., 55.3. A cubic meter of air can hold approximately as many grams of water when saturated as shown by the vapor pressure figures just given. The breathing of cool air entails, then, much greater evaporation from respiratory membrane and consequent greater flow of lymph through and secretion of fluid from it. The membrane is better washed and kept clean from infecting microbes by such outflow. The breathing of cold air entails, too, the greater flow of arterial blood through the membrane in order to keep it warm, and at the same time warm the inhaled air. Vigorous open-air exercise may increase the volume breathed five times, and this on a cold day means far more blood, lymph and secretion fluid washing the respiratory membrane. The open-air worker is thus better protected, while he escapes the massive infection from "carriers" which occurs in shut-up rooms. It is the bronchitic with chronic inflammation and those with acute catarrh who should not expose themselves to the change of atmosphere between room and wintry out of doors. What suits the bronchitic and those in the state of "chill" from infectious catarrh must not be taken as suitable for the healthy.

For them dryness of cold air is not trying, for the Alpine resorts are most bracing and health-giving. In the sirocco in Palestine the relative humidity sank to 2 per cent, the temperature being 43° C. In the Alpine winter midday the physiological saturation deficit may be even lower, that is, the difference between the vapor pressure of the air and the vapor pressure of the air saturated at body temperature, that is owing to the small amount of vapor held in the air at the low temperature there pertaining (Dorno). One gram of water evaporated takes away 600 calores of heat, so the sweating mechanism is very effectual, but it must fail in *saturated* atmospheres at temperatures at or near to body temperature. In hot, dry atmospheres it may become exhausted, especially in the sick, e. g., those suffering from constipation, malaria, etc. A wet sheet put on the body, and a fan set to blow on this, prevents heat stroke in a hot, dry atmosphere by setting up an artificial evaporation. A hot, dry wind may heat the body by convection more than it can be cooled by the evaporation of sweat; to prevent this effect Arabs, in a sandstorm, crouch on the desert and cover themselves with their robes. Moist, warm atmospheres are trying and reduce the efficiency of workers, because of the difficulty of getting rid of body heat. If the air is stagnant, the layer entangled in the clothes becomes saturated and raised to skin temperature.

Wet-bulb temperatures in factories and mines are physiologically much more important than dry-bulb temperatures; so too the vapor-pressure reading is much more important than the relative humidity, and the velocity of movement of the air is most important of all, for on this chiefly depends cooling by convection and evaporation. The dry-bulb thermometer indicates the average effect of the temperature of the air and walls of the inclosure on itself; it does not show the cooling and evaporative power of the environment on the skin and respiratory membrane. It is a static instrument while the body is dynamic, producing heat which must be lost at an equal rate. To measure cooling and evaporative powers, I have introduced the kata thermometer, a large-bulbed spirit thermometer of standard size and shape, graduated between 100° and 95° F. The bulb is heated in hot water in a Thermos flask until the meniscus rises into the small top of the bulb. It is then dried, suspended, and the time of cooling from 100° to 95° F. taken with a stop watch in seconds. The number of seconds divided into a factor number (approximately 500, and determined for each instrument) gives the cooling power by convection and radiation on the surface of the "kata" at approximately skin temperature in millicalories per square centimeter per second. The operation is repeated with a cotton muslin finger stall on the bulb and the wet "kata" cooling power obtained, a cooling power due to evaporation, radiation, and convection.

The difference between the two gives the evaporative cooling power. In Britain the mean dry "kata" cooling power on the top of observatories is from 20° to 25° (F.) in July and August, and about 40° (F.) in December and January. Extensive observation shows that the dry "kata" cooling power is about 6 in ordinary rooms occupied by sedentary workers. It certainly should not be less than 6 excepting under conditions of outside temperature which make it impossible to secure such a cooling power by means of fan ventilation. It is frequently found to be as low as 4 and even 3 in factories and offices when proper attention to ventilation would easily secure readings of 6.

When physical work is being done the reading should be higher, say 7 or 8 and even more when labor is being performed. By keeping the cooling power in proper relation to the work done and heat output of the worker—four times as much energy is spent by the body in heat as in doing external work—the latter can be kept from sweating, and working with comfort and ease he will be naturally stimulated to give greater output.

At Stewart & Lloyds, Halesowen, a large steel tube drawing factory, clusters of large air ducts have been installed over the heads and to the side of the workers in front of the furnaces. The air current from these is so great that when the furnace doors are shut one feels too cold and moves away. The men are warmed by radiant energy and cooled by wind alternately as they draw the tubes from the furnaces or pause. The effect is as congenial as the sun on a breezy day coming in and out from white clouds. The output here is greater than from any other factory of like kind, and there is no industrial unrest. An enormous improvement in health and efficiency will follow the general application of a proper cooling power to the work in hand. The heat output of different classes of workers is exemplified by the following estimates:

Man.	Additional k. cal. per hour required for work.	Woman.	Additional k. cal. per hour required for work.
Tailor	44	Seamstress	6
Bookbinder	81	Typist	24
Shoemaker	90	Sewing machinist	24–57
Carpenter	116–164	Bookbinder	38–63
Metal worker	141	Housemaid	81–157
Painter	145	Washerwoman	124–214
Stonemason	300		
Man sawing wood	378		

How much greater is the cooling power of wind than of change of temperature in stagnant air is shown by the following:

TABLE XIX.—*Cooling power by radiation and convection in millicalories per square centimeter per second exerted on dry "kata" surface at 36.5° C.*

[The loss by radiation is assumed to be the same as in a chamber, the walls of which are at the given temperature.]

Temperature, °C.	9 meters per second, 20 miles per hour.	4 meters per second, 8.8 miles per hour.	1 meter per second, 2.2 miles per hour.	0.5 meter per second, 1.1 miles per hour.	Still air.
0	62.0	45.6	27.7	22.6	9.8
5	53.5	39.4	23.9	19.5	8.5
10	45.0	33.1	20.1	16.4	7.1
15	36.5	26.8	16.3	13.3	5.8
20	28.1	20.6	12.5	10.3	4.4
25	19.5	14.3	8.7	7.1	3.1
30	11.2	8.1	4.9	4.0	1.7
35	2.3	1.9	1.1	0.9	0.4

I have calculated that the tailor would require a dry kata cooling power of 6, the carpenter 8–10, the stonemason 15, and the man sawing wood 18 to keep him from sweating.

The "kata" can be used as an anemometer, the formula connecting temperature and wind with the cooling of the dry "kata" having been marked out in wind tunnels. The formula, as stated in my Report to the Medical Research Council on the Science of Ventilation and Open-air Treatment (Spec. Rep. Series 32 and 52 H. M. Stationery Office, London), was

$$H/\theta = 0.29 + 0.49\sqrt{v}$$

The above figures are calculated on this formula.

Renewed investigation at a low range of velocities gave the following as more correct:

$$H/\theta = 0.12 + 0.54\sqrt{v}$$

and for velocities below 0.4 meters per second

$$H/\theta = 0.165 + 0.42\sqrt{v}$$

The wet "kata" reading is found to be about 18 to 20 in rooms which do not feel close where sedentary work is being done. In warm moist spinning sheds and mines it may be as low as 10 to 12. The wet "kata" reading is of great importance when the temperature approximates to body temperature, and cooling by convection and radiation becomes greatly reduced. Evaporation from the wet "kata" depends on the vapor pressure and wind, and the latter has a very great effect. A formula has also been worked out for the wet "kata." It must be borne in mind that the "kata" indicates cooling and evaporative powers from its own surface, not from the human body. Its bulk is comparable to the body of a mouse, and is much smaller than the parts of a human body. The "kata" readings give valuable measures of cooling and evaporative powers, but not directly measures of the cooling and evaporative loss of the body. The stimulating and suggestive lines of inquiry into the relation of health to weather and atmospheric environment, opened up by Prof. E. Huntington, require to be carried out farther with attention to readings of cooling and evaporative powers.

An extensive series of observations on people sitting in ordinary clothes indoors or outdoors exposed to the wind shows that the metabolism is correlated very closely with the dry "kata" cooling power. The cheek temperature varies greatly with exposure, e. g., from say 35° C. in overwarm factories, 33° C. in factories which do not feel close, to 20° C. or even lower out of doors exposed to cold winds. The cheek temperature also has a close relation to the metabolism when people are exposed out of doors to cool conditions. Exposure to cold wind may double the metabolism of a man sitting at rest. His natural inclination is not to sit still and feel chilled, but be active and keep himself warm. It is to this impulsion to activity and raising of metabolism that open-air life largely owes its beneficial effect.

In the winter climate of North America the cold outside air when heated up becomes very dry and increased evaporative power acting on the skin indoors cools the body. There is, too, no source of intense radiant heat (a fire) in the rooms, thus high temperatures of 70° F. or more are habitual.

If the air could be moistened, lower temperatures would be found adequate as in England where a temperature of 63° F. is considered sufficient in an office heated by hot-water radiators with natural ventilation and no sensible draft, or with a plenum system.

In the Tropics there is required the building of houses so that through draft is everywhere obtained, with wide verandas (ventilated), double roofs with ventilated air space (the vents screened to keep out animals), whitened walls, fan ventilation. The clothes must be of the lightest texture and worn widely open at neck, sleeve, and knee to allow ventilation. The skin should be allowed to pigment so that a gauzy material can be worn without sunburn resulting. Sleep should be taken on roofs where convection and radiation heat losses are greatest; a mat should take the place of a mattress, a cradle over the body covered with a sheet kept wet by a

spray or drip, and a fan to cool by evaporation may be used in hot, dry weather. The diminution of protein food, which stimulates metabolism and heat production, is indicated. Monkeys fed on rice and ripe bananas stand exposure to tropical sun out of doors. The taking of vigorous outdoor exercise keeps men much fitter in the Tropics than women shut up and cooking in houses. The body weight can be diminished to six-tenths of the pre-war figure safely, according to German reports on the effect of the blockade on the civilian population. A diminution particularly of heavy weights in the Tropics is an obvious advantage, the surface exposure being thus increased in proportion to the mass of the body.

In England belief in the open or gas fire as a source of radiant warmth is justified. The moist, misty, mild weather is thus counteracted. Gas fire must replace coal fires to secure economy of coal energy and remove the pall of smoke, dirt, and destruction of vegetable life from the towns and the great loss of health and wealth these entail. The theory that chemical purity of the air is the one important thing has permitted the establishment of slum cities, underground places of business, office rooms lighted by wells, etc.

It must be realized that the carbonic acid is never increased or the oxygen reduced in crowded rooms so as to harm, to the least extent, the occupants. Moreover, after exhaustive experiments by physiologists, proof is not forthcoming of those subtle organ poisons supposed to be exhaled by human beings. Massive saliva spray infection from carriers of pathogenic germs, and the physical state of the atmosphere depressing the vitality, these are the agents which cause ill health.

The garden city provides outdoor exercise to be taken in games and gardening, and the interests natural to most men of perfecting the homestead and raising stock and plants. Rabbits and fowls yield protein food, goats yield milk, and this and the green foods secure ample supplies of essential amino acids and vitamines. The man with his eight-hour day at the factory has his leisure filled in by productive work and he and his family are kept well fed, exercised, interested, healthy, and happy. The garden city with its factories is the main solution of health troubles of civilized people. With the garden city must go discipline, through education of the young, in the simple ways of keeping fit and enjoying life.

NOTE IN REGARD TO INDOOR AND OUTDOOR HUMIDITY.

In the discussion of indoor and outdoor humidity and temperature and its relation to disease and health, found on page 504 of the MONTHLY WEATHER REVIEW for September, 1920, the following points seem to have been overlooked:

(1) The kind of indoor heat is not stated, whether steam, direct-indirect, hot air, or stove. The "common home" is usually heated by stove or by hot-air furnace. Country schools are heated by stoves. The fluctuations of temperature and humidity would be greater with such heat and would more nearly correspond to those outdoors.

(2) Practically all the indoor temperatures cited are above what has been accepted as the optimum for human health and for mental activity, viz, 65 to 68°. New York State institutions are now required to keep the temperature at this figure. The data cited would seem to indicate that the heat was by steam and the temperature intended to be kept at about 73°. It ran up as high as 89°; the lowest was 64° F.

(3) The relative humidities are correspondingly below the optimum.

(4) If the indoor temperature is kept near the optimum of 65 to 68°, the indoor relative humidity will be higher; the body will not be constantly overheated; there will be less contrast between outdoor and indoor temperature. Sweating of the room walls will be much less apt to occur when the indoor humidity is high.

(5) Movement of the air in the room is a factor that is important to comfort and health.—*John R. Weeks.*

NOTE IN REGARD TO THE PRIMARY CAUSE OF COLDS.

It would seem that the conclusions of Dr. C. M. Richter, in 1913, quoted in the MONTHLY WEATHER REVIEW for September, 1920, page 507, in regard to the primary cause of a "common cold" are not in accord with the most recent medical thought.

The expired air from the lungs is normally near the saturation point when it passes over the mucous membranes of the nose and throat, therefore saturated air, per se, can not cause a discharge from and congestion of the mucous membranes. The air commonly enters dry and passes out moist; therefore it can not be a change from dry to moist air, per se, that would cause coryza. Even the hyperesthetic membrane is accustomed to these differences.

In recent studies of ventilation the effects of breathing saturated and humid air for varying periods have been observed. Breathing warm, saturated air *while the body is immersed in it* raises the body temperature, causes discomfort, and is injurious if there is no air circulation, but has not, I believe, been shown to cause irritation and hypersecretion in the mucous membranes of the nose and throat. Similarly, experiments have shown that chilling of the body surface causes an ischemia (anæmia) of the mucous membranes of the nose and throat instead of a hyperemia as was formerly supposed.

It may be suggested in explanation of the observed greater prevalence of colds with cyclonic weather that previous dry weather has made dust which the winds have carried from the streets to our nostrils and throats, causing mechanical irritation and bacterial implantation and growth. An amplification of this phase of the subject is given by Dr. Oliver T. Osborne, professor of therapeutics at Yale University, in an excellent article on the "common cold" that appears in the Handbook of Therapy, third edition, published by the Journal of the American Medical Association.

If we define a "common cold" (acute coryza) as an inflammation and congestion of the mucous membranes of the nose and throat, then the best medical evidence is that a "common cold" is in the great majority of cases caused by bacterial invasion. If we ask what causes or allows bacterial invasion, the answer is too long, diversified, and complicated for these pages.—*John R. Weeks.*

CLIMATE AND HEALTH, WITH SPECIAL REFERENCE TO THE UNITED STATES.[1]

By ROBERT DE C. WARD.

[Presidential address before the American Meteorological Society at Chicago, Dec. 29, 1920.]

(Author's Abstract.)

In the statement of the objects of the American Meteorological Society, the relation of meteorology to the

[1] To be published partly in the *Scientific Monthly* and partly in the *Boston Medical and Surgical Journal.*